This document has been redacted for Critical Energy/Electric Infrastructure Information ("CEII") (2/24/25).

Beaver River – Porter 115 kV Transmission Rebuild Project

Exhibit E-4

Engineering Justification

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EXHIBIT E-4: ENGINEERING JUSTIFICATION

E-4.1 ENGINEERING JUSTIFICATION AND RELATIONSHIP TO EXISTING FACILITIES

The Accelerated Renewable Energy Growth and Community Benefit Act (the "Act") requires the Public Service Commission ("Commission"[1]) and New York's utilities to plan the electric transmission upgrades necessary to meet the clean energy and climate goals established under the Climate Leadership and Community Protection Act ("CLCPA"). By way of further background, on September 9, 2021[2], the Commission determined that there were numerous Areas of Concern that were in critical need of Phase 2 local transmission investment under the CLCPA. On March 8, 2022[3], National Grid and other utilities proposed transmission investment within the Areas of Concern to address this critical need ("Utility Proposed Areas of Concern"). On February 16, 2023[4], the Commission approved National Grid's proposed investments, including the project that is the subject of this filing.

As part of its investments, Niagara Mohawk Power Corporation d/b/a National Grid ("National Grid" or the "Applicant") proposes to rebuild several 115 kV transmission lines extending approximately 60.32 miles from the proposed Beaver River Substation in the Town of Croghan, Lewis County, to the Porter Substation in the Town of Marcy, Oneida County. The Project is herein referred to as the Beaver River – Porter 115 kV Transmission Rebuild Project or the Beaver River – Porter Project. The Project is located within the Towns of Croghan, Leyden, Lowville, Martinsburg, New Bremen, Turin, Watson and West Turin and the Villages of Croghan,

[1] In this exhibit, the term "Commission" and numerous other capitalized terms are defined in the Glossary included in this Application.

[2] Case 20-E-0197, Proceeding on Motion of the Commission to Implement Transmission Planning Pursuant to the Accelerated Renewable Energy Growth and Community Benefit Act, Order on Local Transmission and Distribution Planning Process and Phase 2 Project Proposals (issued September 9, 2021) (https://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId={6A0FAE50-5710-42DD-969A-5116171E2457}).

[3] See https://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId={4BAD2A2F-9C14-4D1D-9C83-FDD2C2346F13}.

[4] Case 20-E-0197, Proceeding on Motion of the Commission to Implement Transmission Planning Pursuant to the Accelerated Renewable Energy Growth and Community Benefit Act, Order Approving Phase 2 Areas of Concern Transmission Upgrades (issued February 16, 2023) (https://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId={0C1FE2AF-2922-BF5-809C-5C93F4F73121}).

Lowville, and Turin in Lewis County, and in the Towns of Boonville, Floyd, Marcy, Steuben, and Trenton and the Villages of Boonville and Holland Patent in Oneida County, New York.

The Watertown/Oswego/Porter Area of Concern is a 115 kilovolt ("kV") network across a large geographic area covering portions Franklin, St. Lawrence, Jefferson, Lewis, Oswego, Oneida, and Onondaga Counties. The elements that are the subject of this filing are an important portion of this network. Historically the main purpose of this network was to serve customer load. Recently new generators, primarily large scale solar and land-based wind, have proposed to connect to this network. Figure E-4.2-1 is a single line representing this area and Figure E-4.2-2 is a geographic map. The purpose of the Project is to rebuild the 115 kV elements to increase the amount of energy the circuits can transmit from generation to load or from generation to system on ramps that move the power out of the local area.

The northern transmission path of the system starts with a single circuit from Willis to Malone, a single circuit from Malone to Colton, two (2) circuits from Colton to Browns Falls and two (2) circuits from Browns Falls to Taylorville. At Colton a loop connects Colton, Dennison, Alcoa, McIntyre, Corning, Battle Hill and back to Colton. Power can flow in and out of the system at Willis and Alcoa, with both providing connections back to the existing 230 kV system. The Browns Falls to Taylorville circuits are the only paths out of the area to the south.

The western transmission path of the system starts at Taylorville, with two (2) circuits connected to Black River, one (1) circuit connecting Black River and Lighthouse Hill, one (1) circuit connecting Black River and Coffeen and one (1) three (3) terminal line connecting Black River, Coffeen and Lighthouse Hill. At Lighthouse Hill one (1) circuit connects to Clay and two circuits connect to South Oswego.

The southern transmission path of the system starts at Taylorville, with two (2) circuits connecting to Boonville. At Boonville two (2) circuits connect to Porter and two (2) circuits connect to Rome, with one (1) circuit connecting Rome and Oneida and two (2) circuits connecting Oneida and Porter.

An existing bulk power system runs loosely in parallel with this local system. The local system is only connected to the bulk system at Willis and Moses in the north and at Clay, Oswego and Porter in the south. Because of the high impedance associated with the long length of the local circuits, upgrades to the bulk system have a minimal impact on the north to south flows on the local system. Today, outages of portions of the bulk system can cause power to flow into the local system at Willis and flow back out to the bulk system at Moses (via Alcoa Station). The impact bulk system flows can have on the local system will be lessened by the planned conversion of most of the area 230 kV to 345 kV and by the planned Phase Angle Regulator at Malone. The planned project to convert the north to south 230 kV path to 345 kV was included in all study cases.

This area was considered to be one (1) large renewable pocket because outages in any of the three (3) transmission paths directly impact the other two (2) transmission paths and generation added to any part of the region directly impacts the ability to deliver generation in the other parts.

Figure E-4.2-1: Watertown/Oswego/Porter Single Line Diagram

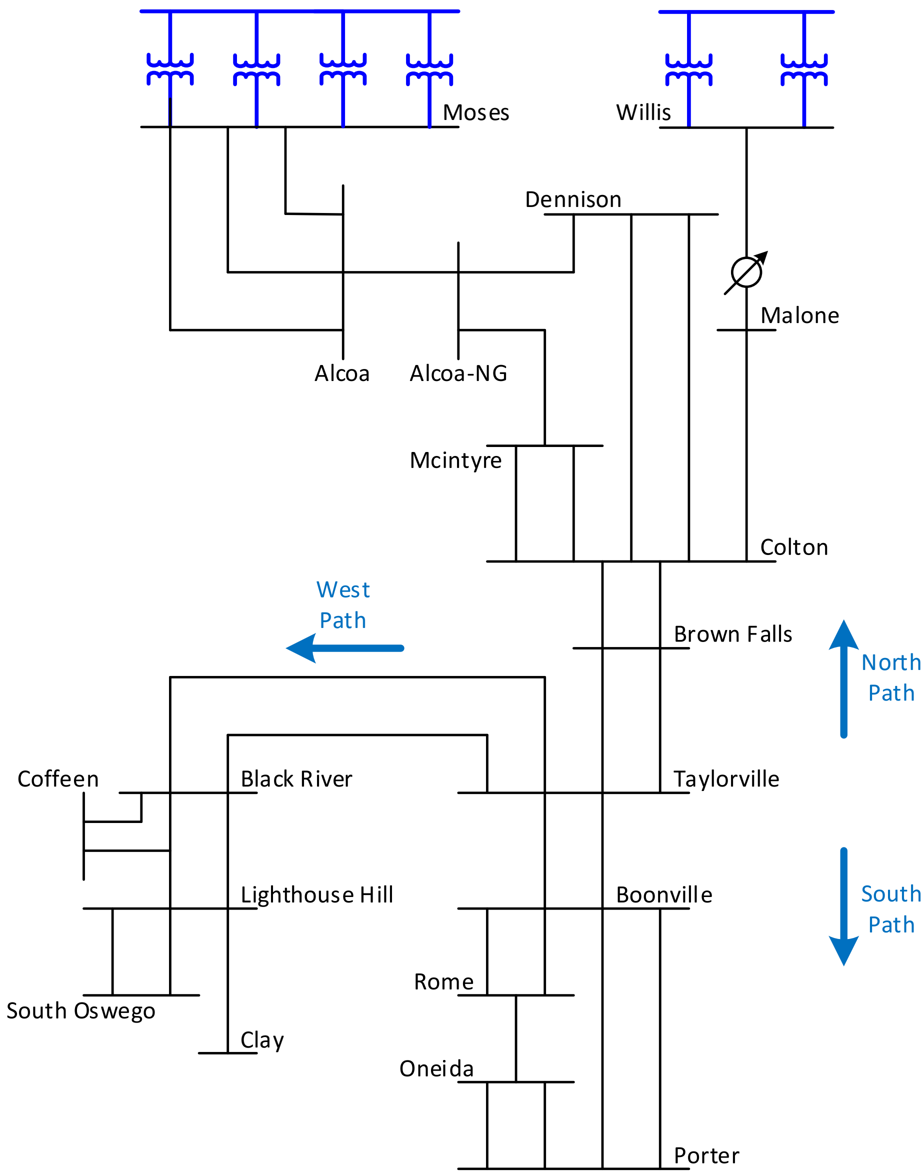


Figure E-4.2-2: Watertown/Oswego/Porter Transmission Map

In order to identify potential outage impacts, National Grid evaluated several aspects of the transmission paths. As detailed in the March 8, 2022 filing, a scope was developed to perform an assessment of system performance. The scope included assumptions for generation additions, generation dispatch and area load assumptions. These outage conditions are defined by national, regional, and local standards such as the North American Electric Reliability Corporation ("NERC") Transmission System Planning Performance Requirements TPL-001-5. All of these standards require system performance to be evaluated for a fault on adjacent circuits on a multiple circuit structure, often referred to as a Double Circuit Tower ("DCT") outage. National Grid performed the assessment and found that many portions of the Watertown/Oswego/Porter network were overloaded for various generation dispatch assumptions and that renewable generation would have to be curtailed to maintain system loading and voltage within acceptable limits.

Based on the study base cases, several N-0 and N-1 conditions were identified that would constrain the output of generation (generation pocket). Before any outages occur, several areas of the system were found to be loaded beyond the circuits' summer normal rating.

[redacted]

For N-1 outage conditions the loading is significantly higher, and overloads exist on more facilities. The maximum post contingency loading on each corridor is summarized below. The data is summarized in this format as the complete list of branch and contingency combinations for all cases is [redacted] Over 120 contingencies were found to create the overloads including line outages, bus outage, multiple circuit tower outages and breaker failures.

[redacted]

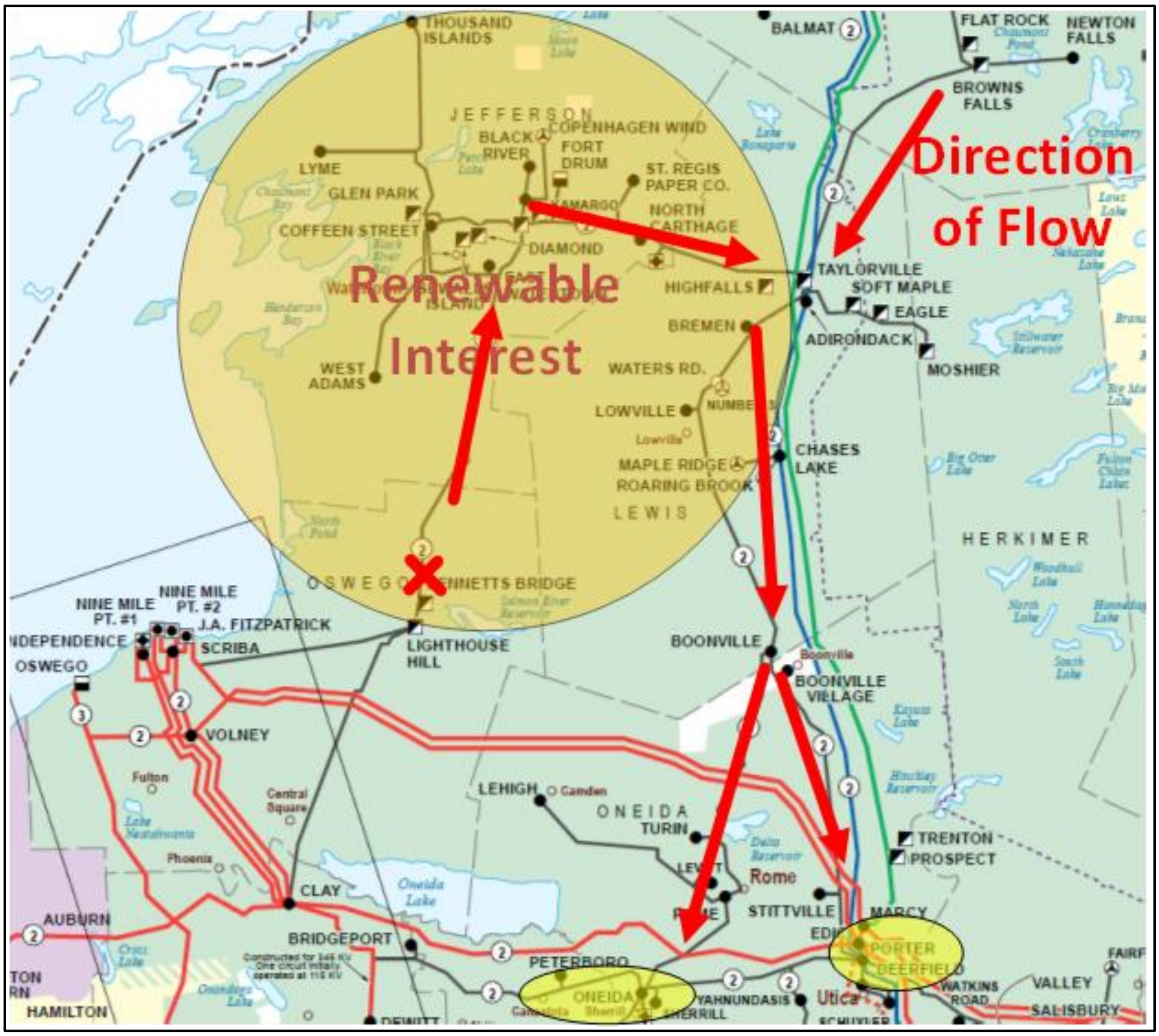
In addition, within this region, evaluations of system performance found that many DCT outages resulted in the highest thermal loading and the lowest system voltages, all well outside acceptable system performance. While developing solutions to address these performance issues it was determined that it would not be possible to address the low voltage conditions and thermal overloads without eliminating the DCT outages.

The thermal issue is best explained with an example focused on the generation connected in the area around Black River station. Black River has two (2) lines that travel toward Taylorville and two (2) lines that travel toward Lighthouse Hill. All power must flow out of the Black River area along these four (4) lines. With circuits installed on double circuit structures, system performance is evaluated for loss of two (2) of the four (4) lines and the maximum amount of capacity that can be supported is no more than the rating of the two (2) remaining lines. Thus, after the lines are rebuilt, but if they remained on double circuit structures, the maximum that could be supported based on the estimated ratings of the two (2) lines is about [redacted] If all DCT outages are eliminated, then the worst-case outage the system would need to be evaluated for is loss of any one (1) of the four (4) lines. In this case, which is what is proposed to be built, the maximum capacity that could be supported is approximately the rating of three (3) lines or [redacted] If the double circuit configuration remains, [redacted] or one third (1/3) of capability, is lost. This is an approximation and would need to be refined by power flow simulations but is close to what detailed studies would show. In the Areas of Concern study, the total generation in the area exceeded [redacted] and would have to be curtailed if the DCT outages remained. Options to further increase the circuit ratings were evaluated but were ruled out as not feasible due to equipment limits and the voltage issue discussed in the following section.

Similar concerns are observed for DCT outages when evaluating voltage performance. If the double circuit structures are not eliminated, following some DCT outages, the system splits into two. The best example of this is an outage of both circuits between Black River and Taylorville. When the system is split in two, the system essentially becomes radial from Thousand Island, Coffeen and Black River down to Lighthouse Hill, a distance exceeding 50 miles. Prior to the addition of generation to this area, acceptable system performance is observed for this condition. Once hundreds or even thousands of MW of generation are installed, this power trying to travel from the Thousand Island region down to Lighthouse Hill station creates voltage drop along the system. Voltage drop is proportional to current flow. The higher the current flow due to the added generation, the higher the voltage drop. Following the double circuit tower outage that splits the system in half, the voltage drops due to the large amount of power flowing towards Lighthouse Hill results in voltage drop that is so severe, voltage collapse is expected. If the DCT outages are not eliminated, it would be necessary to place a limit on area generation to prevent voltage collapse. Based on past studies, this limit is approximately 70% of the installed nameplate capability assumed in the Areas of Concern study. Loss of 30% of the planned capability is about a [redacted] reduction. Other solutions, such as the addition of dynamic reactive devices, were evaluated and found to be insufficient to address this problem.

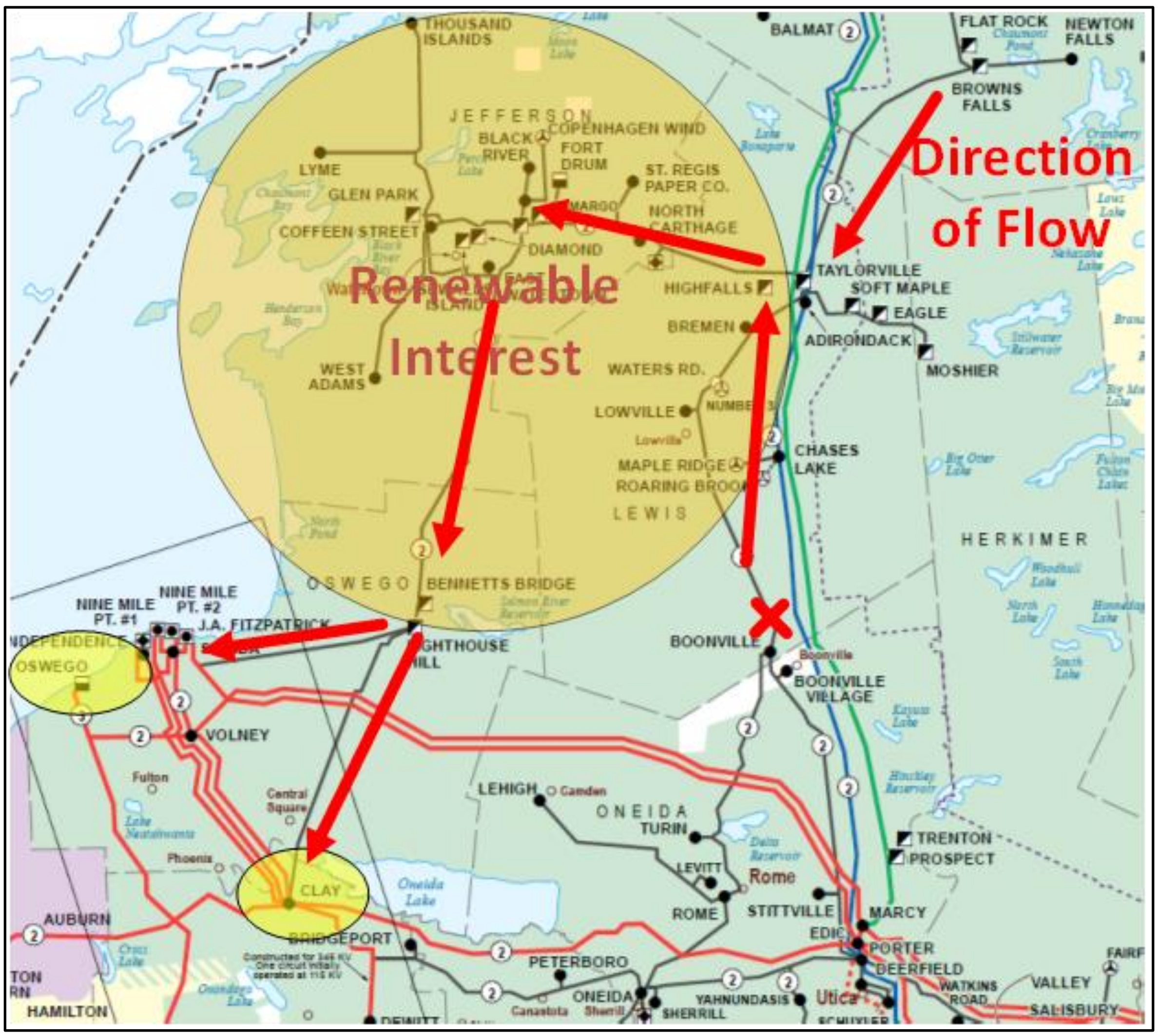
From the list of critical area outages two (2) example contingencies were selected for further discussion to illustrate the types of issues that this region is exposed to. The first example of a significant area contingency occurs for a double circuit tower outage of the circuits north of Lighthouse Hill, designated by the red “X” in Figure E-4.2-3. For this contingency all power in the Coffeen/Black River area is forced to Taylorville where it is added to power from the northern and southern transmission paths of the system. [redacted] Once the power reaches Boonville, most of the flow heads towards Porter, but some heads to Rome, Oneida and then to Porter. The highest loading on the southern transmission path of the system for this outage was Taylorville – Boonville at 332% of Long-Term Equipment ("LTE") and Boonville – Porter at 212% of LTE, both in a shoulder load case with generation dispatched to 100%. The Black River – Taylorville circuit was also at 323% of LTE in that same case.

Figure E-4.2-3: Western Transmission Path Contingency Impact



The second area contingency of concern occurs for a double circuit tower outage of the circuits north of Boonville, designated by the red "X" in Figure E-4.2-4. For this contingency all power in the Coffeen/Black River area, the northern transmission path and connected between Taylorville and Boonville is forced to Lighthouse Hill. [redacted] Once the power reaches Lighthouse Hill, flow heads towards Clay and South Oswego. The highest loadings on the western transmission path of the system for this outage was the Lighthouse Hill – Clay circuit at 417% of LTE, the Black River – Lighthouse Hill circuits as high as 317% of LTE and the Lighthouse Hill – South Oswego circuits at 136% of LTE. These overloads occurred in the peak load case with Existing and Expected Generation dispatched to 100% of nameplate.

Figure E-4.2-4: Southern Transmission Path Contingency Impact



These two (2) examples represent the types of concerns in the region and are not meant to be a comprehensive review of all overloaded elements. While all the previous issues described thermal overloads, voltage issues were also found in this area. The voltage analysis assumes all area capacitor banks are in service and area generators are providing the maximum amount of reactive support possible without violating voltage limits. At 100% dispatch widespread voltage collapse is observed for several double circuit tower and stuck breaker outages. These outages push large amounts of generation to one (1) side of the network or the other, across a large distance, resulting in high flow across high impedance, leading to voltage collapse. This cannot be corrected with switched capacitor banks and screening has suggested that use of dynamic reactive support would not address the issue unless many devices were strategically placed throughout the region. This cannot be corrected with switched capacitor banks or the use of dynamic reactive support. The complete summary of critical voltage issues is included in Table E-4.3. The voltages for the 70% dispatch are generally acceptable, but the system may be close to the collapse point.

Two (2) other issues were also observed at the 100% dispatch. The Boonville/Rome area voltage is below limits for outages of the Oneida – Rome circuit due to sagging voltage at Boonville. The South Oswego – Lighthouse Hill area voltage is below limits for outages at South Oswego or Clay due to sagging voltage at Lighthouse Hill. The sagging voltage at Boonville and Lighthouse Hill are also caused by the high-power flow through the area causing voltage drop.

Table E-4.3 Existing System Area Voltage Results

Outage	40% Generation Dispatch	70% Generation Dispatch	100% Generation Dispatch
DCT:5S&6S	-	88%	Collapse
DCT:5N&6S	-	-	Collapse
DCT:5S&6N	-	-	Collapse
DCT: TAY 2B+8B	-	-	Collapse
DCT: BVL TAY 5B+6B	-	-	Collapse
DCT: BVL TAY 5C+6C	-	-	Collapse
SB: BLACKRV R8105	-	-	Collapse
SB: TAYLOR R8105	-	-	Collapse
DCT: 5N&6N	-	-	84%
LN: ROME ONEI 1A	-	-	87%
SB: ALCOA R8105	-	-	87%
BUS: ALCOA NG	-	-	88%
SB: SOSW R815	-	-	86%
BUS: SOSW B	-	-	87%

Table E-4.3 Existing System Area Voltage Results			
Outage	**40% Generation Dispatch**	**70% Generation Dispatch**	**100% Generation Dispatch**
LN: LHH CLAY 7	-	-	88%
DCT:1&2	-	-	89%
DCT:1&6	-	-	90%
LN: LHH BLKRV 6S	-	-	90%
NF:10 SOSW	-	-	93%
LN: SOSW 9MI1 1	-	-	93%
LN: FITZ 9MI1 4	-	-	94%
BUS: 9MI1	-	-	94%

To quantify the impact of these thermal and voltage issues a security constrained dispatch test was performed. This test looks to correct overloads by reducing generation dispatch, similar to how system operators secure the system during day-to-day operations. However, this test is done to minimize the amount of curtailed generation and does not consider price. The curtailment identifies the most impactful generation on each constraint or on multiple constraints and reduces that generation. Because this is an ideal or minimal amount of curtailment necessary to address overloads, the amount of curtailment does not reflect any consideration of flexibility when dispatching generation, especially for price considerations.

With 1404 MW of nameplate wind and solar generation in the study cases and the need to curtail up to 1130 MW in the 100% dispatch case, only 274 MW of the 1404 MW output could be delivered. To deliver the 274 MW of generation many generators had to be turned off completely. The 274 MW of generation represents 20% of the area generation.

With 1404 MW of nameplate wind and solar generation in the study cases and the need to curtail up to 670 MW in the 70% dispatch case, only 313 MW of the 983 MW output could be delivered. To deliver the 313MW of generation many generators had to be turned off completely. The 313 MW of generation represents 22% of the area generation.

With 1404 MW of nameplate wind and solar generation in the study cases and the need to curtail up to 260 MW in the 40% dispatch case, only 302 MW of the 562 MW output could be delivered. To deliver the 302 MW of generation many generators had to be turned off completely. The 302 MW of generation represents 22% of the area generation.

The Area of Concern base case and headroom testing identified numerous severe violations. The majority of overloads under optimistic (i.e., less impactful) load levels range from 100% to 475%.

One viable alternative that would allow the existing circuits to be rebuilt and remain on double circuit structures is the addition of new circuits to the area. This new third circuit would not eliminate the need to rebuild the existing circuits. The addition of a third circuit between the existing switching stations at Porter, Boonville, Taylorville, Black River, Lighthouse Hill, Clay, and South Oswego would result in similar thermal and voltage performance compared to the elimination of the double circuit towers.

The Project which is the subject of this Application is needed to provide necessary transmission reinforcements that have been presented to address certain limits that were identified and evaluated in submissions made to the Commission regarding certain Areas of Concern. In addition, as described further in Exhibit E-1, to provide the needed capability transmission reinforcements are necessary, including the Project that is the subject of this filing. To provide the needed local system capability and to address a critical voltage issue, several of the circuits are recommended to be constructed on single circuit structures, eliminating the existing double circuit structures and the associated need to secure the system in planning and operations for an outage of both circuits on the double circuit structures.

In addition, the Rebuild of the Beaver River – Porter transmission circuits requires the replacement of the Taylorville and Boonville substations. Taylorville will be replaced by Beaver River and Boonville by Gulf Road substations.[5] In each case, not replacing these substations, the existing station equipment, busses and configuration would be the limiting elements in the system and the line project would not be able to achieve the goals to connect and deliver Renewable Energy out of the Area of Concern in support of the State's Clean Energy Goals.

E-4.2 RELIABILITY, ECONOMIC BENEFITS AND SYSTEM IMPACT STUDIES

E-4.2.1 Reliability

The driver for this Project is not correction of concerns with area circuits availability or the need to keep system performance within reliability criteria. However, the proposed rebuild of these

[5] Note that the decommissioning of the Taylorville Substation will be included in a separate Article VII application.

transmission elements will be done in accordance with a comprehensive, state-of-the-art design incorporating transmission structures that meet National Grid's standards. While age is not always an indicator of condition, in the absence of condition assessments, the relative age of a circuit can provide some insight into how close the circuit may be to end of life refurbishment or replacement. Circuits that are rebuilt are expected to see increased availability due to a reduction in the number of outage events compared to older assets.

Table E-4.4 is a list of area circuits with the age of the oldest components. Weighted by circuit mileage, the weighted average circuit age today is 96 years and would reach 102 years old by 2030. Following completion of all transmission investments in this region, the weighted average circuit age will drop below 50 years.

Table E-4.4 Transmission Circuit Age

Circuit	Year	Age	Mileage
Colton - Browns Falls #1	1912	112	30.5
Colton - Browns Falls #2	1912	112	30.6
Lighthouse Hill - Clay #7	1913	111	26.1
Taylorville - Boonville #5[1]	1920	104	33.4
Taylorville - Boonville #6[2]	1920	104	33.9
Ogdensburg - McIntyre #2	1921	103	2.5
Browns Falls - Taylorville #3	1922	102	26.8
Browns Falls - Taylorville #4	1922	102	26.8
Boonville - Porter #1	1923	101	26.8
Boonville - Porter #2	1923	101	26.8
Colton - Battle Hill #7	1923	101	32.0
McIntyre - Colton #8	1923	101	31.4
McIntyre - Corning #6	1923	101	11.2
North Ogdensburg - McIntyre #9	1923	101	0.9
Black River - Middle Road #8	1924	100	4.9
Middle Rd - Lighthouse Hill #6	1924	100	30.7
Coffeen - Black River - Lighthouse Hill #5	1924	100	45.2
Dennison - Colton #4	1924	100	28.5
Dennison - Colton #5	1924	100	28.5
Black River - Taylorville #2	1925	99	26.1
Black River - North Carthage #1	1925	99	11.9
North Carthage - Taylorville #8	1925	99	14.1
Boonville - Rome #3	1925	99	24.1
Boonville - Rome #4	1925	99	26.2
Indeck Oswego - Lighthouse Hill #2	1926	98	28.5
FitzPatrick - Lighthouse Hill #3	1928	96	25.6
Nine Mile Pt. #1 - FitzPatrick #4	1928	96	0.6

Table E-4.4 Transmission Circuit Age			
Circuit	**Year**	**Age**	**Mileage**
South Oswego - Indeck Oswego #6	1928	96	4.3
South Oswego - Nine Mile Pt.#1 #1	1928	96	10.3
Levitt - Rome #8	1930	94	20.4
Rome - Oneida #1	1930	94	12.5
Colton - Malone #3	1932	92	38.4
Corning - Battle Hill #4	1932	92	26.4
Battle Hill - Balmat #5	1940	84	6.0
Coffeen - Black River #3	1959	65	7.7
Alcoa - Dennison #12	1961	63	3.0
Alcoa - North Ogdensburg #13	1961	63	35.0
Thousand Islands - Coffeen #4	1962	62	19.6
North Gouverneur - Battle Hill #8	1971	53	4.9
Coffeen - West Adams #2	1982	42	14.1

[1] The Taylorville – Boonville #5 Line is also known as the Taylorville – Waters Road #5 and #6 Lines.
[2] The Taylorville – Boonville #6 Line is also known as the Waters Road – Boonville #7 and #8 Lines.

E-4.2.2 Economic Benefits

The driver for this Project is not achieving economic benefits. However, three (3) potential qualitative benefits are likely.

Because the Project replaces assets that are at or beyond their useful life, it is likely that the cost to maintain these elements in good working order, including addressing damage or failures on an as needed or annual basis and the disruptions to service, would be reduced compared to doing nothing.

The increase in the capacity of the system to support renewable generation may also result in improved market efficiencies. Increasing the amount of energy available from low-cost renewable generation could displace the need to operate higher cost resources.

As discussed in the order approving the Areas of Concern Projects, the structure of New York State Energy Research and Development Authority's ("NYSERDA") Renewable Energy Credit ("REC") procurement program currently imposes the risk of curtailment due to transmission congestion on generation developers and thus indirectly on ratepayers who fund the RECs that they earn. This arises because generators finance projects based on their expected wholesale market revenues and RECs (i.e., their two (2) sources of cash flow). When the risk of curtailment due to transmission system limitations is high, generation developers must assume their volume of energy and REC sales will be reduced. Therefore, to ensure adequate overall compensation for the projects, generation developers will raise their REC bid prices above the level that might be economical if curtailment was not a risk. With approval of the National Grid plans for this area, developers can consider these system improvements in future REC bid prices.

E-4.2.3 System Impact Studies

The New York Independent System Operator ("NYISO") requirement to perform a System Impact Study ("SIS") (i.e., voltage, thermal and stability analyses) is primarily driven by whether the project is expected to have a positive or negative impact on interface capability within New York or between New York and its neighbors. Interface capability is a measure of the ability to move power across the state. Because the projects within the Watertown/Oswego/Porter Area of Concern focus on moving power within the local area or from the local area to the rest of the system, statewide interface capability is unlikely to be impacted.

National Grid has performed an assessment of the impact the projects within this area could have on interface capability. National Grid is in the process of discussing the results with NYISO, which concluded that an SIS is not necessary. Following the discussion with NYISO staff that a SIS is not necessary, the expectation is that NYISO Staff's concurrence will be communicated to the NYISO Transmission Planning Advisory Subcommittee. Once that occurs, documentation of the same will be filed with the Commission.

E-4.2.4 Impact of a Delay in the Construction Schedule

The proposed projects in the Watertown/Oswego/Porter Area of Concern are all scheduled to be completed by December 31, 2029. This date was chosen to align with the CLCPA requirement that 70% of New York's energy needs come from renewable generation. Failure to complete the projects on time would reduce the amount of energy available from generators within this region and could jeopardize achievement of state policy.